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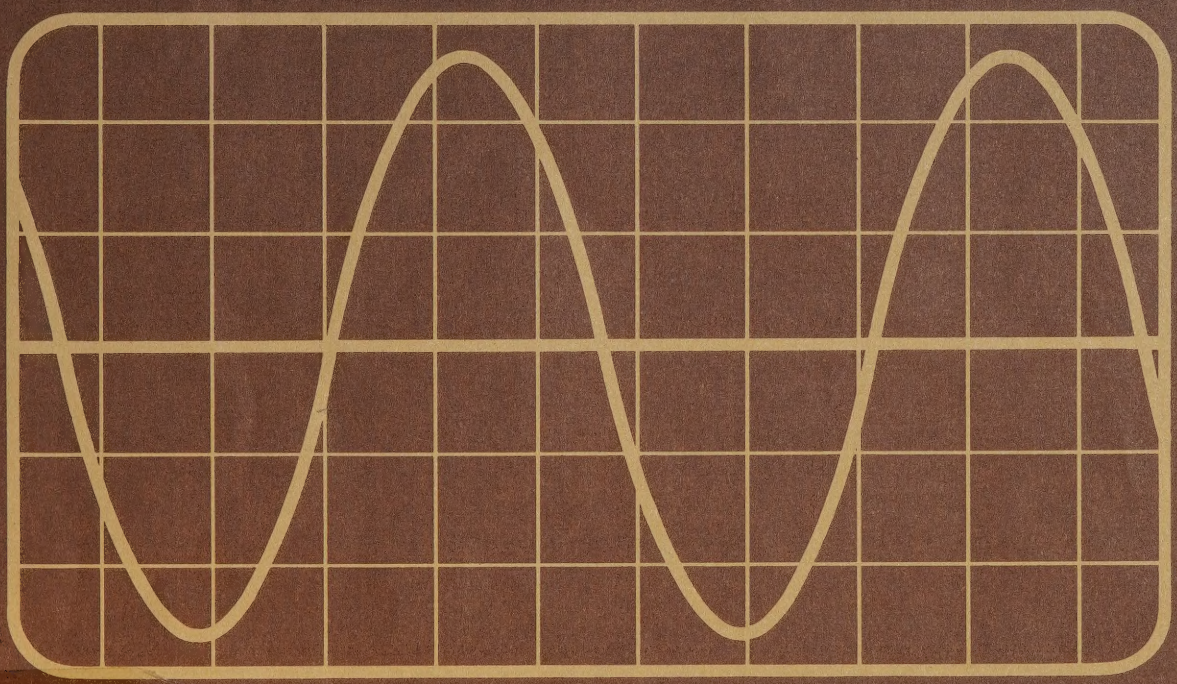
SENIOR DIVISION ADVANCED-LEVEL PHYSICS

A Report Card for Ontario



PROVINCIAL REVIEWS

CHEMISTRY AND PHYSICS

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SENIOR DIVISION ADVANCED-LEVEL PHYSICS

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Introduction

The Senior Division advanced-level course in physics is usually taken by students during their third or fourth year in secondary school. Students taking the course often plan some form of postsecondary education. Many students follow this course with the Ontario Academic Course (OAC) in physics to prepare for university programs in the sciences. This report card provides for the citizens of Ontario a summary of the results of the recent Provincial Review of Senior Division Advanced-Level Physics.

What is a provincial review?

Provincial reviews form a part of the Ministry of Education's ongoing commitment to the monitoring of programs in schools. Reviews inform the public about the performance of the Ontario educational system, as well as provide information to schools and school boards to assist them in program improvement. Provincial reviews are conducted by the Ministry of Education for the following purposes:

- to provide a curriculum-based process of public accountability for the province and for local school boards
- to determine the level of student achievement and program effectiveness at the provincial level as a basis for public reporting and decision making
- to identify strategies that will ensure effective implementation of ministry guidelines
- to establish baseline information on both student achievement and program effectiveness for comparison with future reviews
- to provide instruments, procedures, and baseline information for use by schools and boards in local reviews

Sample Questions From the Review

Several of the questions used in the review have been included in this report card. The first six are selected-response questions and are presented in order of the content domains outlined in this report card. Under each question are three boxes for the Anglophone responses and three for the Francophone responses.

Anglophone	76	85	62
Francophone	75	88	70

From left to right, the boxes indicate the following:

1. the percentage of students who answered the question correctly
2. the percentage of teachers who indicated that students had had the opportunity to learn the knowledge or skills required to answer the question correctly
3. the percentage of students that teachers predicted would correctly answer the question

The last sample question (#7) is an extended-response question.

The correct answer for each question can be found on the last page of this report card.

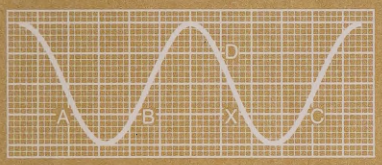
1. A baseball of mass 0.200 kg has a speed of 31.0 m/s. Its kinetic energy is:

   a) 3.10 J.
   b) 6.20 J.
   c) 12.4 J.
   d) 96.1 J.
   e) 192 J.

Anglophone	34	94	68
Francophone	34	100	68

Students study both kinetic and potential energy and the transformation from one form to the other. This question requires that they apply the formula for the calculation of kinetic energy.

2. The following diagram shows different points labelled on a wave.



   Which one of the labelled points is the same phase as point X?

   a) A
   b) B
   c) C
   d) D
   e) none of these

Anglophone	76	85	62
Francophone	52	78	52

Phase *is a term associated with the study of vibrations and the importance of the direction of the vibration. This leads to a study of the relationship between vibrations and waves and the definition of* wavelength.

How was the information collected?

Information was provided by students, teachers, and school boards in Ontario. A total of 6794 students and 230 teachers from 185 schools offering instruction in English, and 852 students and 34 teachers from 32 schools offering the course in French, participated in the provincial sample. Individual students and teachers were not identified in any of the review results.

In addition to the provincial sample, 39 school boards chose to participate in the review process by conducting board reviews. These 197 schools, 264 teachers, and 7269 students participated in a manner identical to those in the provincial sample schools.

What kinds of information were collected?

The review collected the following information:

- courses of study prepared at the school level to indicate learning objectives, teaching strategies, evaluation techniques, and resources
- details about teaching strategies used in the physics classrooms, including resources, methodologies, and evaluation techniques
- student-achievement data, indicating students' knowledge of physics, their ability to apply physics concepts, and their ability to perform tasks involving higher-order thinking skills
- information on student attitudes towards physics and the physics course

Although the provincial review collected information in all of these areas, this report card is limited to reporting on student achievement and student opinions on science-related issues. A more detailed report of the complete results of this review may be found in the publication *Senior Division Advanced-Level Physics: Educators' Report*, available in both English and French versions.

What aspects of the Senior Division advanced-level physics course were included in the review?

The Senior Division physics course is a survey course, designed to provide students with an understanding of the concepts and principles involved in fundamental physics. The experimental approach is emphasized whenever possible.

Student achievement was measured in the following six content areas, which were common to the guideline issued in 1966 and the new guideline released in 1987:

- *Mechanics:* speed, velocity and acceleration, force, Newton's laws of motion, gravitational force, work, energy, power
- *Waves and Sound:* vibrations and waves, the wave equation, interference of waves and sound, resonance
- *Light:* reflection and refraction, including index of refraction, lenses, and optical instruments
- *Current Electricity:* electrical circuits, resistance, Ohm's law, power, the cost of electrical energy
- *Electromagnetism:* magnetism, electromagnetism, the motor principle, electromagnetic induction, motors, transformers
- *Atomic Structure and Nuclear Physics:* atomic structure, radioactivity, structure of the nucleus, nuclear reactions, fission, fusion, applications of nuclear physics

Students were also asked their opinions about their approach to learning physics, science education in general, the use of computers, and the role of science in society.

3. The phenomenon of light bending as it passes from air into oil is described as:

   a) refraction.
   b) diffraction.
   c) interference.
   d) specular reflection.
   e) diffuse reflection.

Anglophone	79	89	73
Francophone	73	90	70

This question requires a knowledge of the definition of refraction. *The study of refraction leads to the investigation of the behaviour of light as it travels through various transparent materials, including lenses used in many applications.*

4. A *total* resistance of 3.0Ω is to be produced by connecting an unknown resistance to a 12Ω resistance. What must be the value of the unknown resistance and how should it be connected?

   a) 3.0Ω in parallel
   b) 3.0Ω in series
   c) 4.0Ω in parallel
   d) 4.0Ω in series
   e) 6.0Ω in parallel

Anglophone	57	87	45
Francophone	59	100	59

Students are taught to solve problems involving resistances in series and parallel arrangements. This question, however, is complex. Students are given the total resistance and asked to work backward to determine what will produce this result. They must realize that the resistances have to be connected in parallel and must know the correct relationship involving the addition of fractions.

How was student performance measured?

A team of physics educators chose ninety-five selected-response (multiple-choice) questions from the student assessment section of the Ontario Assessment Instrument Pool (OAIP) – Physics and developed five additional selected-response questions. The OAIP is a large collection of test items available to physics teachers since 1982. In addition, five questions were created to which students were asked to prepare a detailed written response. All questions were related to the six content areas selected for the review.

Student assessment questions were rated as to the complexity of processing needed to answer them correctly. Three levels of questions were used in this review:

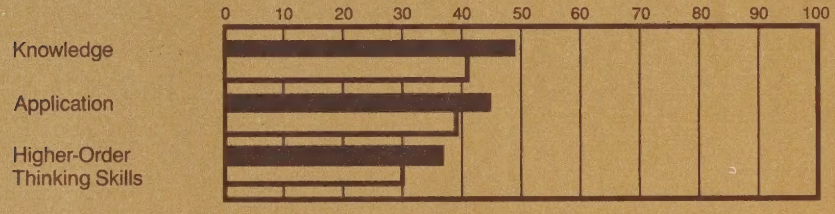
- *knowledge:* questions that could be answered by recalling factual information
- *application:* questions that required applications of factual information to new situations
- *higher-order thinking skills:* questions that required several reasoning steps or the application of concepts from a number of areas of the course

How well did students perform?

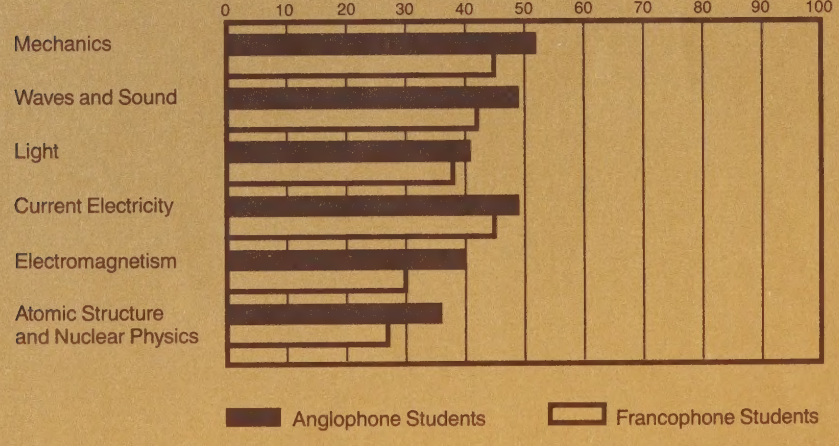
Students from Anglophone schools responded correctly to 45 per cent of all selected-response questions, while Francophone students responded correctly to 38 per cent of the questions. The results by content area and thinking skill are shown in the accompanying graphs. Students' responses to the extended-response questions were at similar levels of achievement.

Percentage of Students Answering the Questions Correctly

by Process Level



by Content Domain



5. A permanent magnet is held stationary in the centre of a coil connected to a galvanometer. The current reading on the galvanometer will:

a) be steady and zero.
b) be steady and not zero.
c) steadily increase.
d) steadily decrease.
e) steadily increase and then decrease.

Anglophone	41	66	49
Francophone	30	61	43

This question requires an understanding of the conditions necessary for the induction of a current in a wire, which is basic to the study of electromagnetism, the study of generators and alternating current.

6. A gamma ray source and a Geiger counter are positioned on a laboratory bench. The Geiger counter reading is 300 counts per minute. A sheet of metal 6.00 mm thick is placed between the source and the counter. The reading on the counter is now 75.0 counts per minute. If the thickness of the metal is reduced to 3.00 mm, the reading on the counter will be closest to:

a) 75.0 counts per minute.
b) 150 counts per minute.
c) 300 counts per minute.
d) 450 counts per minute.
e) 600 counts per minute.

Anglophone	67	14	18
Francophone	56	22	21

Although the context of this question is nuclear physics, the answer can be obtained strictly from the numerical data. This topic is investigated during the study of radioactivity. The shielding effects illustrated here have direct application in the safe use of radioactive materials.

The differences between Francophone and Anglophone achievement can be attributed to many factors, including the following:

- a scarcity of experienced Francophone teachers. Over one-third of the Francophone teachers of Senior Division science have less than four years' experience, compared to 15 per cent in Anglophone schools.
- larger classes. One class in five in French-language schools has more than thirty students, compared to 12 per cent in Anglophone schools.
- lack of a regular review of the course. Only one teacher in seven in Francophone schools reported that the course had ever been reviewed. Seven in ten teachers in Anglophone schools regularly conduct reviews.
- the limited availability of French-language science resource material (e.g., texts, visual aids, films, videos)

Was student performance satisfactory?

The results of student performance were presented to an *interpretation panel* consisting of science educators, trustees, representatives of the business community, supervisory officers, members of faculties of education, and Ministry of Education personnel. The panel examined student responses to each question and rated them on a five-point scale: superior, strong, satisfactory, marginal, or weak. The panel found the following results for the 100 selected-response (multiple-choice) questions:

Content Domain	Francophone Students	Anglophone Students
Mechanics	marginal	satisfactory
Waves and Sound	satisfactory	satisfactory
Light	marginal	marginal
Current Electricity	satisfactory	satisfactory
Electromagnetism	marginal	satisfactory
Atomic Structure and Nuclear Physics	marginal	marginal

When achievement was rated in terms of process level, the results for Anglophone students were deemed satisfactory in each process level. The results for Francophone students were rated as satisfactory in knowledge but marginal in application and higher-order skills.

Student achievement in the extended-response (essay-type) questions for both language groups was quite varied. Each of the questions was responded to by one-fifth of the students. The questions dealt with a wide range of topics and asked for responses of about a page in length.

In a question in which students were asked to make measurements of distance on a diagram, complete a data table, and describe the motion of an object, the interpretation panel found the Anglophone students' results to be satisfactory and the Francophone results to be marginal. Similar ratings were given to results for a question involving the drawing of a force vector diagram and the determination of the net force and the resulting acceleration and velocity. The other questions involved drawing and labelling ray diagrams, solving problems on the refraction of light, and describing the scientific method and designing an experiment. The interpretation panel rated both Anglophone and Francophone results as marginal.

7. a) List the sequence of key steps a scientist takes when solving a problem which involves an experiment. This sequence of steps is normally called the scientific method.

b) Imagine that you have been hired by a company that manufactures light bulbs to test a new material to be used in making light bulb filaments. The company has asked you to determine how the lifetime of a new filament is related to the electrical potential difference applied across the filament. By referring to each step of the scientific method you identified in part (a), describe an experiment you would perform to solve the problem posed by the company. Pay particular attention to the control of variables.

Students have been asked initially to outline their knowledge of procedures and then to apply that knowledge to a specific problem. It is essential that students transfer the skills and processes learned in the classroom and laboratory to other problem-solving situations. This question also examines students' ability to organize and express ideas clearly and concisely.

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Answers to questions

1. (d)
2. (a)
3. (a)
4. (c)
5. (a)
6. (b)

What do the results say about science education in Ontario?

The findings regarding students' achievement in physics in this review are similar to those in two other recent studies – the Ontario Assessment Instrument Pool (OAIP) Field Trials in 1983 and the Second International Science Study (SISS), as reported in the *Ontario Science Education Report Card* in 1987. While this provincial review found similar areas of concern with respect to student achievement, the information gathered on teaching practices, student opinions, and resource use will be extremely valuable in the science curriculum renewal process now under way. These results certainly reflect weaknesses in some aspects of science education in Ontario, and they have been addressed in the science curriculum reform now taking place at all grade levels in Ontario schools. The Ministry of Education is working closely with professional organizations to ensure that the results of this review will be used in a constructive manner to ensure that the science education that takes place in Ontario classrooms is of a high quality.

What was learned about the students who take physics?

Of the students taking physics, less than half of all students were female (47 per cent of the Francophones and 42 per cent of the Anglophones). This is a slight increase from the results of a similar survey done in 1983 (38 per cent female) and perhaps reflects recent efforts to encourage young women to continue in science courses. Most students (88 per cent of the Anglophones and 87 per cent of the Francophones) expect to continue their education beyond secondary school, and many (59 per cent of the Anglophones and 56 per cent of the Francophones) expect to include science courses in these future plans.

What were students' opinions on science-related issues?

Students were asked their opinions on a variety of topics. More than four out of every five students valued hands-on laboratory work as an aid to understanding concepts. Approximately three-quarters of the students perceived the value of scientific training in future careers, and a large majority did not consider a person's sex as a factor in determining ability in, or the need for, scientific pursuits. Students also indicated that they believed that science is an important factor in the development of our country and the improvement of our standard of living. Their opinions are, however, divided on whether public money spent on scientific endeavours has been used wisely and on the effect of science on the environment. A majority of students perceived physics as a difficult, yet an enjoyable and interesting subject.

How will the results of the review be used?

The individual schools and school boards involved in the review have been provided with their results as well as suggestions for the analysis and interpretation of these results for use in program planning and for local reporting. It is expected that the information from this provincial review will be an important resource in the process of introducing and implementing the new science guidelines.

The Ministry of Education has published this report card for public information as well as a more detailed report on all aspects of the review for educators.

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